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SOVIET INDUSTRIAL DEVELOPMENT

NO. 12

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Introduction

This is a serial publication containing selected translations on industrial development in the Soviet Union. This report contains translations on subjects listed in the table of contents below.

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a. Method of Determining the Economic Effectiveness of New Technology in Ferrous Metallurgy

/This is a translation of an article written by A. Leskov in Planovoye Khozyaystvo (Planned Economy), No. 1, January 1960, pages 38-48./

The June (1959) Plenum of the CC CPSU designated a most important national-economic task -- the technical refurbishing of the existing metallurgical enterprises and the omnilateral introduction of over-all mechanization and automation of production. Plans exist for a broad use of fluxed sinter, raising the temperature of blast and the pressure of top gas in blast furnaces, utilization of natural gas and oxygen in blast-furnace and steel-smelting operations, expansion of the converter and electrometallurgical methods of steel production, introduction of the continuous teeming and vacuum treatment of steel, high-speed rolling of metal, production of economical sections of rolled stock, and other measures. The Plenum of the CC CPSU decided to assign priority to the conduct of measures for the over-all mechanization of such most labor-consuming processes as the production of rolled stock, tubes and metal hardware and, in the field of automation, to focus special attention on a practical solving of the problem of the transition from the automation of individual production operations to the creation of totally automated technological processes, shops, and enterprises.

The new technology in ferrous metallurgy makes it possible to produce more and better pig iron, steel and rolled stock at minimal expenditures of labor. This concerns both the live labor expended at a given enterprise and the past labor materialized in the form of raw materials, fuel, electrical energy, and other resources needed for producing ferrous metals. Thus, the economy in social labor is one of the principal criteria of the effectiveness of application of new technology.

The determination of the decrease in outlays of social labor on the production of pig iron, steel and rolled stock upon the introduction of new technology involves considerable difficulties, because of the lack of a precise calculation of the scope of these outlays. Therefore, indexes of decrease in production costs may serve as a first approximation for determining the effectiveness of the introduction of new technology.

Another very important index of determining the effectiveness of the introduction of new technology is recoup-

ability, i. e., the ratio of the related capital expenditures to the resulting difference in the reduction of production costs. The employment of new technology is expedient only when the resulting reduction in production costs compensates the capital expenditures incurred by introducing that technology within a short period of time. The shorter the period of recoupment of the executed capital investments the greater the gain in funds and time.

The appraisal of the effectiveness of any given technical measure cannot be based on a single index only, be it production costs, magnitude of the unit capital expenditures or the period of recoupment of these expenditures. A more correct idea about the effectiveness of the new technology can be provided only by a complex whole of indexes characterizing to such or such extent the change in the outlays of social labor resulting from the conduct of a given measure. These indexes are constituted by the changes in volume of output, production costs, unit capital expenditures, and level of labor productivity. Moreover, the determination of effectiveness should also be based on those other results of the introduction of a given measure which cannot always be quantitatively determined and are merely subject to a general evaluation, e. g., the improvement in the quality of metal and in working conditions and labor safety, reduction of construction time, etc.

As adopted in the present article, the methods of determining the economic effectiveness of the introduction of new technology into ferrous metallurgy are fundamentally reducible to the following.

Primarily, the savings in the nominally fixed expenditures and in fuel are determined. From these savings we then subtract the cost of the additional resources expended on the introduction of a given measure. If the economic analysis shows that such an introduction leads to an increase rather than a decrease in the production costs of metal, then the proposed version has to be rejected as ineffective.

Proceeding from the determined changes in the productivity of metallurgical assemblies and the consumption coefficients of raw material, fuel, and other resources, the magnitude of the necessary capital investments into metallurgy and allied branches is determined according to the old and the new technologies, respectively. In the event that the introduction of a given measure causes an increase in capital investments, the difference between their new and previous extent, as related to the resulting savings in production costs, yields the index of the period of recoupability of the additional capital investments. A sufficiently short period of recoupability (up to five or six years) will

attest to the effectiveness of a given measure and the expediency of its introduction. If the magnitude of capital investments involved by new technology is smaller than that of those involved by the old technology, then it is no longer necessary to calculate the period of recoupability.

The most important method for determining the effectiveness of application of a given measure in ferrous metallurgy should be the calculation of the change in the labor input of metal production as expressed in man-hours per ton of metal. The most applicable version of using a given measure is the one which makes it possible to attain the maximally feasible reduction in the labor input of metal production upon also taking into account the labor outlays in the allied branches of industry.

Tables 1 and 2 cite the average and most often encountered values of the effectiveness of a number of the most vital measures for the introduction of new technology into blast-furnace and open-hearth production.

The data cited in these tables serve as the basis for executing below economic calculations which do not claim a high accuracy but, as a first approximation, make it possible to deduce a number of extremely important practical conclusions.

* * *

The Soviet ferrous metallurgy ranks first in the world with regard to technical and economic indexes of blast furnace work. The best such indexes have been attained by the metallurgists of Magnitogorsk and Cherepovets. The ratio of useful blast furnace volume to daily production, as reached by these metallurgists, amounts to 0.58-0.61, and their unit consumption of coke per ton of pig iron amounts to 0.61-0.7 ton. These results were obtained primarily thanks to the use of pace-setting technology and a proper organization of production. Even in the United States, where half-year's reserves of ore are kept on ore yards, the attained degree of ore averaging is lower than in our pace-setting plants. For instance, at the Magnitogorsk Metallurgical Combine, despite the absence of an ore yard in its blast-furnace shop, 95 percent of the assays of ore-charge samples display variations of only $\pm$0.5 percent in iron content.

Our plants have organized the separation of ore fines and their sintering. Of great importance is the fluxing of sinter, because then the sinter is more easily reduced thanks to its lack of the difficultly reducible compound of ferrous oxide with silica. The fluxed sinter exerts yet another

Table 1

Comparison of Effectiveness of Blast-Furnace Measures

Type of Measure	Rise in Furnace Productivity, in %	Saving in the Consumption of Coke per ton of Pig Iron
Enrichment of Blast With Up to 25 Percent of Oxygen When Smelting Pig Iron for Steel Making	12-15	40-80 kg
Conversion of Furnaces From Run-of-Mine Ore to 100-percent Fluxed Sinter	25-30	20-25%
Replacement of 50 percent of Run-of-Mine Ore in Blast-Furnace Charge by Fluxed Sinter and Reduction of the Consumption of Raw Limestone to 150 kg per ton of Pig Iron	12-15	10-12%
Increase in the Pressure of Gas in Furnace Throat by 0.6-0.8 atm.	6-7	30-50 kg
Increase of Blast Temperature by 100°C and Humidity by 7-9 grams/m^3	4-5	3.5-3.8%
Conversion of Furnaces to the Smelting of Low-Manganese Pig Iron	6-9	1.2-1.6%
Reduction of the Slag Yield by 100 kg per ton of Pig Iron	5-6	5.6-5.9%
Increase of the Iron Content of Blast-Furnace Charge by One Percent	2-2.5	1-1.2%
Reduction of the Sulfur Content of Coke by 0.1 percent	--	12-30 kg
Reduction of the Ash Content of Coke by One Percent	--	15-20 kg

Table 2

Comparison of the Effectiveness of Open-Hearth Measures (in percent)

Type of Measure	Rise in Furnace Productivity	Saving of Fuel
Use of Basic Refractories (Magnesite-Chromite in Furnace Arches and Forsterite in the Checkerwork)	10-15	4-6
Automation of Thermal Regime	6-8	4-5
Standardization of Charge	6-8	3-4
Increase in the Weight of Melting Stock by 10 percent	6-8	3-4
Doubling of the Weight of Melting Stock	50-60	25-30
Increase in the Volume Weight of Metal Scrap by 10 percent	3-5	1-2
Increase in the Volume of Molds by 10 percent	2-4	1-2
Cleaning of Coke Gas from Sulfur	3-8	2-4
Intensification of Processes by Compressed Air	5-20*	2-12*
Intensification of Processes by Oxygen	5-75*	2-50*

positive effect on blast-furnace smelting by eliminating the introduction of limestone into blast-furnace charge. And besides, in turn, the elimination of 100 kilograms of limestone reduces the consumption of coke by 40-50 kilograms. It is therefore necessary to endeavor to transfer all limestone from blast-furnace charge to sintering charge, in which the limestone decomposes by burning with a low-grade fuel.

The pace-setting metallurgical enterprises produce a sinter with a basicity of 1.4 and higher. This has made it possible completely to eliminate limestone from blast-furnace charge, to reduce by approximately four percent the consumption of coke, and to raise by 13-15 percent the productivity of blast furnaces. In our plants the content of sinter in charge amounts to about 75 percent, while in the United States it is only 28 percent, in England -- 31 percent, and in

* According to the unit consumption of compressed air and oxygen per ton of steel and the methods of their application.

West Germany -- 35 percent.

The good preparation of raw material and the sintering of ore fines made it possible to raise blast temperature to 900-1,000°C and to maintain a fixed blast humidity by blowing in 25-30 grams of steam per cubic meter of air. This progressive development increases blast-furnace productivity by five to seven percent and reduces coke consumption by two to three percent. Only a few West German plants can maintain such a high blast temperature. In the United States blast temperature does not exceed 600-700°C.

A considerable effect is yielded by the transition to the smelting of low-manganese pig iron with withdrawal of manganese ore. Manganese ore, particularly in the East, is very expensive and usually it contains more silica than manganese; therefore it requires a lot of limestone for fluxing, which is conductive to an increase in the amount of slag (every 100 kg of slag cause the consumption of an additional 50-60 kg of coke) and reduces the smelting-out of pig iron.

The technology of blast-furnace smelting at a higher pressure of gas in furnace throat has been developed and broadly introduced. In 1958 in the USSR over 80 percent of all pig iron was smelted out in high-pressure blast furnaces, whereas in the United States only 31 such furnaces operated at high pressure, and in England and West Germany -- two furnaces each. An increase of pressure by 0.1 atm boosts productivity by 0.4 percent, conservatively estimated.

It is necessary to propagate broadly the experience of the pace-setting collectives of the Magnitogorsk and Kuznetsk metallurgical combines and the Zaporozh'ye and Cherepovets plants, as well, in the preparation of raw material for blast-furnace smelting, production of a highly basic strong and easily reducible sinter, improved concentration of ores, and improved dressing of coals for coking.

To increase the smelting-out of pig iron, raise labor productivity and reduce the production costs of ferrous metals, new blast furnaces with a volume of two thousand and more cubic meters will be built during the seven-year period. During capital repairs it will be necessary to modernize a great part of the existing furnaces and maximally to increase their volume. Plans exist for shutting down the greater part of the small technically obsolete blast furnaces in the Urals.

The pace-setting metallurgical enterprises of the USSR -- the Magnitogorsk, Kuznetsk and Nizhne-Tagil' combines, the Chelyabinsk, Cherepovets and Zaporozh'ye plants -- have utilized to a major extent most of the known measures for raising the level of blast-furnace production, and reached good indexes of furnace utilization and of reduction in coke

consumption. The most important potential for a further increase in the smelting-out of pig iron in these enterprises is the blowing of natural gas into furnaces and the enrichment of blast with oxygen.

In the next few years the preparation of blast-furnace charge will be radically improved nearly throughout the country, and particularly in the southern plants of the USSR. Other measures for improving blast-furnace production have already been utilized to a fairly full extent in the majority of the enterprises. Consequently, the time has come for a broad use of oxygen-enriched blast and for the blowing-in of natural gas. Such are the principal trends in the development of new technology in blast-furnace production.

In order to execute economic calculations of the effectiveness of the introduction of some new-technology measure in blast-furnace work, it is possible to employ the afore-cited methods of calculations serving to obtain, as a first approximation, with an accuracy sufficing in practice, an answer to the question of whether it is expedient to introduce the given measure not only from the standpoint of the benefits it would yield at the shop and plant but also from the standpoint of its benefits to the national economy as a whole.

Thus, e. g., if the increasing of gas pressure in blast-furnace throat raises the furnace productivity by seven percent, and the consumption of coke is then reduced by 50 kilograms per ton of pig iron, then the economic calculation of the effectiveness of this measure will be as follows:

Calculating the Reduction in Pig Iron Production Costs

The increase in blast-furnace productivity yields a saving in nominally fixed expenses amounting to $0.07 \times 15 = 1.05$ rubles per ton of pig iron ("15" represents the nominally fixed expenses at a given shop).

The reduction of unit consumption of coke yields a saving of $0.05 \times 210 = 10.5$ rubles per ton of pig iron ("210" rubles denotes the production costs per ton of coke at the given shop).

Thus, the production costs of pig iron should decrease approximately by $\frac{1.05 + 10.5}{300} \times 100 = 3.85$ percent ("300" denotes the production costs of pig iron in rubles before the conversion of the blast furnace to the regime of a high pressure of furnace-top gas.

If the blast-furnace shop produces three million tons of pig iron annually, then the savings yielded by the

above measure will be expressed by the extremely impressive figure of (1.05 ≠ 10.5) x 3,000,000 = 34,650,000 million rubles annually. The period of recoupability of this measure, which does not require very high capital expenditures, is very short. The decrease in the expulsion of furnace-top dust alone, thanks to the increase in the pressure of furnace-top gas, compensates nearly completely for both the capital expenditures and the current operating expenses incurred by this measures.

However, this does not mean that the calculations of change in unit capital investments should not be made. It is necessary to take into account expenditures not only at the metallurgical plant itself but also in the allied branches of industry.

Calculating the Change in Unit Capital Investments

Change resulting from the increase in blast-furnace productivity by 0.07x100 = 7 rubles per ton of pig iron ("100" rubles denotes unit capital investments per ton of pig iron in the construction of the blast-furnace shop).

Change resulting from the decrease in the unit consumption of coke by 0.05x875 = 43.75 rubles per ton of pig iron (875 rubles denotes the capital investments in coke inclusive of the capital expenditures in the coal industry).*

Thus, the introduction of this measure yields a saving in capital investments to the extent of 7 ≠ 43.75 ≈ 50 rubles per ton of pig iron or, for the shop as a whole for the year, 50 x 3,000,000 = 150 million rubles.

From the above total it would be necessary to deduct the capital expenditures on the modernization of blast furnaces when converting them to the regime of high pressure of gas at the top; however, these expenditures may be disregarded, as they are comparatively not high and are more than compensated by the savings ensuing from the decrease in the expulsion of furnace-top dust.

Calculating the Change in Unit Labor Outlays

The reduction in unit labor outlays on the production of one ton of pig iron resulting from the conversion of the blast furnace to a regime with a higher top pressure will amount, as a result of the decrease in the unit consumption

*Calculations of the production costs, unit capital investments and labor outlays involved in the production of coke and other resources needed for smelting pig iron and steel can be found in the present writer's book on "Oxygen in Ferrous Metallurgy," published in 1959 by Gosplanizdat.

of coke alone, to 0.05 x 12 = 0.60 man-hours per ton of pig iron ("12" denotes the labor input in the production of a ton of coke, in man-hours, taking into account the labor outlays in the coal industry).

Considering that the given shop smelts out three million tons of pig iron annually, the savings of social labor in the national economy will amount to: 0.6 x 3,000,000 = 1,800,000 man-hours annually, or $\frac{1,800,000}{2,000}$ = 900 men (2,000 denotes the average number of working hours per worker per year, taking into account vacations, days off, holidays, and sickness leaves.

The actual saving in labor will be somewhat higher, because the above calculation did not consider other factors: in particular, it did not consider the labor savings yielded by the increase in blast-furnace productivity and decrease in the expulsion of furnace-top dust.

An approximately the same procedure can be used in calculating the economic effectiveness of the other measures for introducing new technology as well. In order not to encumber this article with mathematics, below, in Table 3, we cite only the results of the related calculations on taking into account not only the change in capital investments and labor outlays but also the related changes in the allied branches of industry.

Table 3

Economic Effectiveness of the Introduction of New Technology Into Blast-Furnace Operations

Type of Measure	Reduction in Pig Iron Production Costs, in %	Reduction in Unit Capital Investments, in %	Reduction in Labor Input, in man-hours per ton of Pig Iron
Conversion of Furnaces from Run-of-Mine Ore to Fluxed Ferromanganous Sinter	5-6	5-6	1.2-1.4
Raising of Gas Pressure in Furnace Top by one atm	3-3.5	2.5-3	0.5-0.6
Raising of Blast Temperature by 100°C and Blast Humidity by 7-9 grams/m^3	2.5-3	2-2.5	0.4-0.5
Enrichment of Blast with Three Percent of Oxygen	1-1.5	0.5-1	0.3-0.4
Blowing of Natural Gas and Oxygen Into Furnace	10-15	8-10	2-3

All the above-enumerated measures may and should complement each other, even though the economic effect of their concurrent use will not be equal to their sum.

* * *

About 90 percent of all steel produced in our country is smelted out in open-hearth furnaces. Despite the rising share of the smelting-out of steel in converters and electric furnaces, the increase in steel production, as stipulated by the 21st CPSU Congress, will be achieved primarily through open-hearth operations.

The technological progress in open-hearth furnaces is determined primarily by increasing the productivity of these furnaces and improving the quality of the steel smelted-out in them. Furnace productivity hinges mainly on increasing the weight of the metallic charge, shortening the duration of melting, prolonging the inter-repair period of furnace operation, and increasing the yield of acceptable steel per unit of the metallic burden charged into the furnace.

The practice of prewar and, particularly, postwar years has shown that the highest productivity is yielded by furnaces with the largest weight of melting stock. The maximal open-hearth furnace productivity was achieved at the Kuznetsk Metallurgical Combine. Were a large oxygen station to be built at that Combine, the effect produced by increasing the weight of the metallic melting stock from 185 to 380 tons would be even greater.

The 500-ton open-hearth furnace activated at the Plant imeni Voroshilov yields even better results. It is necessary to build more 500-ton open-hearth furnaces, since they are the most effective ones. The production of steel per worker per year in the shops with such furnaces could be raised to five thousand tons and more. For comparison, let us note that in the open-hearth shops of the better United States plants steel production is no higher than three thousand tons per worker per year. Later on it will be necessary to design and construct 750-ton open-hearth furnaces. If it becomes possible to master the production and operation of steel-teeming cranes with a lifting capacity of 650 tons, then it will be expedient to build one-chute furnace holding 500 tons of melting stock and two-chute 1,000-ton furnaces. In this case steel should mandatorily be teemed from ladles with two remotely controlled stoppers into ingots weighing not less than 20 tons each.

The weight of the melting stock is also being increased in the existing plants. Thus, at the "Zaporozhstal" Plant, thanks to a lightening of the weight of steel-teeming

ladles and increase in the lifting capacity of cranes, it has become possible to increase the weight of a melt in a 185-ton furnace to 220 tons. This bold experiment should be emulated as broadly as possible. In this way the metallic melt of the two-chute 380-ton furnaces could be increased to 440 tons.

Another potential for increasing steel production and raising the labor productivity of metallurgists lies in shortening the duration of melting. The utilization of this potential is one of the principal and constant tasks of steelsmelters. Oxygen plays an exceptionally important role in reducing the duration of melting. As shown by the experience of the "Zaporozhstal'" and "Azovstal'" steel plants and the Nizhne-Tagil'Metallurgical Combine, the enrichment with oxygen of the air forced into open-hearth furnaces for fuel-burning purposes reduces the duration of melting by 15-20 percent. High consumption of oxygen leads to even more striking results. At the Zaporozh'ye plant, after a 200-ton open-hearth furnace was rapidly charged with heavy-weight metal scrap and the hourly consumption of fuel and oxygen was increased, the duration of an average melting was reduced to four and less hours, i. e., halved.

At present oxygen stations with assemblies producing as much as 15,000 m^3 of oxygen an hour are under construction. Even larger assemblies, to produce as much as 35,000 m^3 of oxygen an hour, are in the design stage. Naturally, the larger-capacity oxygen assemblies will yield cheaper oxygen.

The oxygen produced in the currently existing oxygen stations costs upward of 12 kopeykas per cubic meter. Larger oxygen assemblies will make it possible to produce an oxygen costing five or six kopeykas a cubic meter. Considering the concomitant recovery of argon, krypton and nitrogen in the oxygen stations, and their subsequent utilization in the electrical engineering and chemical industries, the cost of oxygen can be cut to one kopeyka a cubic meter.

At such a low cost of oxygen, any method of using it in steel-smelting production would be profitable. This is why, without awaiting the completion of the process of the gradual cutting of oxygen costs, it is now necessary to experiment in 400- or 500-ton open-hearth furnaces with the recirculation method, which makes it possible to shorten the duration of melting to one-half the time and less.

If these experiments succeed, then their emulation will serve not only to double the productivity of open-hearth furnaces in a number of plants but also to utilize broadly cold natural gas burned in a jet of pure oxygen. Such a design of furnaces will cut by 40-50 percent the costs of constructing open-hearth shops, because this will

dispense with the need for regenerators and gas- and air-converting devices. The furnaces with the simplified design could be built on the level of the plant's floor.

The combined method of utilization of oxygen in open-hearth work, proposed by the Engineers Comrades Sel'kin and Zadalya, is highly promising. The nature of this method consists in that an oxygen-water mixture is blown into the mixer containing over a thousand tons of molten pig iron, and this makes it possible to obtain a desilicized pig iron with higher temperature. The duration of the melting of such a pig iron in large open-hearth furnaces will, as shown by foreign experience, be shortened by more than one hour.

The subsequent blowing of the oxygen-water mixture through the metal in the open-hearth furnace during the intermediate and final melting periods reduces, as shown by the experience of the "Zaporozhstal'" Plant, the duration of melting by more than two hours. Thus the combined employment of the oxygen-water mixture both in the mixer and in the furnace should altogether shorten the duration of melting in a 200-ton furnace by three hours, and if the furnace is fed with oxygen for enriching the torch's flame, by four hours or nearly one-half.

Of course, such an intensive operation of open-hearth furnaces requires the elimination of all bottlenecks in the performance of shops. Primarily, all the lightweight metal scrap should be transformed into heavy-weight faggots, -- and this requires 1,000- and 1,500-ton presses. At an intensive operation of open-hearth furnaces the conventional refractories such as Dinas and chamotte /brick/ are no longer suitable. Magnesite-chromite arches and heads of open-hearth furnaces and forsterite checkerwork have definitely proved their worth in practice. Thanks to the use of these refractories it has become possible not only to raise the temperature of arches and checkerwork, and by the same token to shorten by 8-10 percent the duration of melting, but also to double and triple furnace resistance. Now the furnaces are shut down for repairs only once or twice a year. As a result, the stoppages of furnaces for repairs do not exceed more than seven percent of working time in a number of plants.

Among the measures for increasing the yield of acceptable metal a particularly notable one is the continuous teeming of steel, serving to reduce metal wastes from 10 to five percent, i. e., to halve them. In addition, this dispenses with the needs for constructing mold yards and roughing mills. The process of steel teeming is being mechanized and automated.

The problem of the organization of electric steel smelting production stands in a class by itself. The newest

technology requires an ever-increasing number of various special steels and alloys performing at high temperatures, pressures, and speeds. Such steels are most successfully provided by electric furnaces. Considering the high quality of electric steel and the growth in the country's generation of electrical energy, electric steel smelting production acquires an ever-rising importance. At present electric steel smelting furnaces with an 80-ton capacity have been designed and are under construction. There has arisen the problem of building 180-ton and, in the future, 250-ton electric furnaces. The production costs of steels in such furnaces, which employ oxygen in their operations, will be no higher than the production cost of open-hearth steel.

The construction of 500- and 750-ton open-hearth furnaces, 250-ton converters, and 250-ton electric steel smelting furnaces will make it possible to standardize crane equipment and ladle operations.

A new method, improiving the quality of steel, is its vacuum treatment, which makes it possible to eliminate a large amount of gas from the metal. However, the effectiveness of this method, which raises steel production costs and requires certain capital expenditures, is not calculable, because it is not possible to consider all the benefits accruing to the national economy from the improvement in the quality of steel.

The economic effectiveness of all the above-enumerated measures for /introducing/ new technology is extremely high. This could be exemplified by the economic calculation of such a measure as the modernization of an open-hearth furnace to double the weight of its melting stock, through the organization of the tapping of steel through a doubled chute into two ladles. As already pointed out in Table 2, furnace productivity should then increase by not less than 50 percent, and unit consumption of fuel should decrease by 25 percent.

Calculating the Decrease in Steel Production Costs

The increase of 50 percent in the productivity of the open-hearth furnace yields a saving in nominally fixed expenditures (which in the given shop amount to approximately 30 rubles per ton of steel) equal to 0.5 x 30 = 15 rubles per ton of steel.

The reduction of 25 percent in the unit consumption of fuel yields a saving on the scale of $0.25(0.3 \times 10 + 0.2 \times 80) \approx 5$ rubles per ton of steel ("0.3" denotes the unit consumption of blast-furnace gas in thousands of m^3 per ton of steel at the given shop prior to the conversion of the

furnace to a doubled weight of metallic melting stock; "10" denotes the production cost of one thousand m^3 of blast-furnace gas in rubles; "0.2" denotes the unit consumption of coke gas in thousands of m^3 per ton of steel at the given shop prior to the conversion of the furnace to a doubled weight of melting stock; and "80" denotes the production cost per thousand m^3 of coke gas in rubles).

Thus, the total saving will amount to $15 + 5 = 20$ rubles per ton of steel or about $\frac{20}{400} \times 100 = 5$ percent of steel production cost ("400" denotes the production cost of steel at the given shop, when the furnace is charged with conventional weight of metallic stock, in rubles per ton). If a 200-ton furnace, after the doubling of the weight of its melting stock, smelts out about 300,000 tons of steel annually, the yearly savings should total $20 \times 300{,}000$ = six million rubles.

Actually the reduction in production costs will be somewhat higher, because our calculations did not take into account the reduction in the consumption of refractories and dressing materials caused by the doubling of the weight of melting stock. The resulting savings compensate within a very short period (several months) the capital expenditures on the conversion of the furnace from the conventional to the doubled weight of melting stock.

Calculating the Change in Unit Capital Investments

The 50-percent increase in the productivity of the open-hearth furnace yields a saving of $0.5 \times 25 = 12.5$ rubles per ton of steel in unit capital investments ("25" denotes the unit capital investments on the construction of an open-hearth furnace in rubles per ton of steel).

The 25-percent reduction in the unit fuel consumption yields a saving of $0.25\ (0.3 \times 15 + 0.2 \times 64) = 4.3$ rubles per ton of steel in unit capital investments ("15" and "64" denote the unit capital investments in the production of blast-furnace and coke gases, respectively).

Thus, the conduct of the above measure yields to the national economy a saving of $12.5 + 4.3 = 16.8$ rubles per ton of steel or approximately $16.8 \times 300{,}000 = 5$ million rubles annually per furnace. The actual saving will be somewhat higher, because the calculations ignored the savings in refractories and dressing materials ensuing from the conversion of the furnace from the conventional to the doubled weight of melting stock.

Calculating the Change in Unit Labor Outlays

The reduction in unit labor outlays on the production of one ton of steel ensuing from the conversion of the open-hearth furnace from the conventional to the doubled weight of melting stock will, considering that this measure does not increase the personnel of the furnace brigade and the repair personnel on duty, amount to $\frac{24 \times 2,000}{150,000} = 0.32$ man-hours per ton of steel ("24" denotes the number of personnel in the furnace brigade and of the on-duty repair personnel servicing the brigade throughout three shifts; "2,000" denotes the average number of working hours per worker per year; and "150,000" denotes the yearly increase in the output of steel by the furnace after its conversion to doubled-weight melting stock).

The reduction in unit labor outlays per ton of produced steel caused by the 25-percent decrease in unit consumption of fuel amounts to $0.25\ (0.3 \times 0.7 + 0.2 \times 4.8) = 0.29$ man-hours per ton of steel ("0.3" denotes the unit consumption of blast-furnace gas per ton of steel, in thousands of m^3; "0.7" denotes the labor input in the production of blast-furnace gas; "0.2" denotes the unit consumption of coke gas per ton of steel in thousands of m^3; and "4.8" denotes the labor input in the production of coke gas).

Thus, the total saving of labor will amount to $0.32 + 0.29 \approx 0.6$ man-hours per ton of steel.

At an annual output of 300,000 tons of steel by the furnace, the saving in social labor in metallurgy and the allied branches of industry will amount to $0.6 \times 300,000 = 180,000$ man-hours annually, or about $\frac{180,000}{2,000} = 90$ workers.

The actual saving of labor will be somewhat greater, because the calculations did not take into account the decrease in the consumption of refractories and dressing materials resulting from the doubling of the weight of the metallic melting stock in the furnace.

Approximately the same procedure can be used for the economic calculation of effectiveness of the other measures for introducing new technology as well. However, so as not to encumber this article with ponderous mathematical calculations, only their results are cited here. These calculations were made on taking into account the changes in capital investments and labor outlays in ferrous metallurgy, fuel industry, and electric power stations.

It follows from the data in Table 4 that the most effective measures are the doubling of the weight of the melt-

ing charge in the furnace and the subsequent conversion of such large-load furnaces to heating with cold natural gas burned in a jet of oxygen. Of course, such a drastic increase in the productivity of open-hearth furnaces (more than double) requires a large-scale reconstruction of the ancillary departments of the open-hearth shop. The nature of that reconstruction consists in the following major measures:

(1) Installation of large-capacity faggoting presses for pressing lightweight metal scrap;
(2) Construction of charge-yard and mold-yard doublers;
(3) Elongation of casting spans and organization of the teeming of steel from two-stopper ladles.

Table 4

Economic Effectiveness of New Technology in Open-Hearth Production

Type of Measure	Reduction in Production Costs, in %	Decrease in Unit Capital Investments, in %	Reduction in Labor Input in Steel Production, in man-hours per ton
Increase in the Weight of Metallic Melting Charge of Open-Hearth Furnace by 10 percent	0.5-0.8	0.5-0.6	0.3-0.4
Doubling of the Weight of Metallic Melting Charge of Open-Hearth Furnace	3.5-4	0.6-0.9	0.6-0.8
Shortening the Duration of Melting in Open-Hearth Furnace by 20 percent through the Feeding of Compressed Air to Flame Torch and to Bath	1.8-2	1.5-2	0.2-0.3
Shortening the Duration of Melting in Open-Hearth Furnace by 50 percent Through the Feeding of Oxygen to the Torch and Bath (on burning natural gas in a jet of oxygen)	1.5-5	10-12	1.3-1.5

In the new spacious open-hearth shops under construction it is immediately necessary to build large-load furnaces holding a melting charge of not less than 500 tons, and to fire them with cold natural gas burned in a jet of oxygen.

In the economic rayons with considerable and continually supplemented reserves of metallic scrap it is best to build large electric furnaces with capacities of 180 and 250 tons. As for the rayons which can count solely on the return metallic scrap of metallurgical plants, there it is necessary to build 100-250 ton converters employing oxygen in their operation.

Summing up the afore-cited calculations it may be concluded that all the above-enumerated measures for introducing new technology into ferrous metallurgy are quite effective and provide the national economy of our country with an enormous saving of funds and social-labor outlays, calculable in billions of rubles.

b. Questions Concerning the Combining of Production in Industry

/This is a translation of an article written by V. Fridenberg in Planovoye Khozyaystvo (Planned Economy), No. 1, January 1960, pages 49-58./

The resolutions of the 21st Congress of the Communist Party of the Soviet Union outline a magnificent program for the building of Communism in our country. In the fulfillment of this program a major role belongs to the economically rational forms of the organization of industrial production -- specialization and combining. In this connection, the Seven-Year Plan of Development of the National Economy indicates the concrete trends to be followed for a further perfection of specialization and combining. A rationally conducted and economically effective combining of production in a number of branches of industry will make it possible to uncover considerable production potential and to place it at the service of the national economy.

At present about one-half of the country's gross industrial output is provided by the branches of industry having the optimal conditions for the further development of combining. This includes chemical, petroleum and gas industries, nonferrous and ferrous metallurgy, coke-, shale- and peat-silvichemical and forest industry, and individual branches of food, light, and building materials industries. The long-term plans for the large-scale development of these branches of industry will ensure a substantial increase in output in the combined enterprises, and as a result this will enhance still higher the economic role of this form of the organization of social production.

The conducted reorganization of the system of management of industry and construction /establishment of sovnarkhozes/ has created the most favorable conditions for the development of the combining of production in our country. The management of enterprises of allied branches of industry is, in a number of economic rayons, exercised by special sovnarkhoz boards. In many economic rayons, individual combined enterprises are directly subordinated to the sovnarkhozes.

Combining and specialization constitute progressive forms of the organization of social production, forms serving to ensure a rise in labor productivity and a reduction in material outlays and to create conditions for increasing industrial output without additional capital investments.

The development of rational combining during the first stage of the reorganization of the management of industry was conducted by the sovnarkhozes basically along the following two trends: first, through the merging of kin enterprises located in the same territory and, second, through the establishment of combines based on the merging of independent industrial, transport and, in a number of rayons, agricultural enterprises as well.

The work on the conduct of a rational combining was carried out in a majority of the economic administrative rayons, and it has encompassed many branches of heavy and light industry. For instance, in the Sverdlovskiy Economic Rayon, combining in ferrous metallurgy was conducted on a major scale by the Oblast Party Committee and the Sovnarkhoz upon the request of the workers. Three metallurgical combines were set up there. The largest of them, the Nizhne-Tagil' Combine, was organized on the basis of two metallurgical plants, three ore administrations, a coke-chemical plant, a refractories plant, etc. This had resulted in a considerable increase in the performance indexes of ore miners -- previously a lagging link in the over-all metallurgical cycle of production; also, the blast-furnace men had attained an improvement in the ratio of useful blast furnace volume to daily production, increased their output, relieved hundreds of railroad cars previously needed for hauling coke, etc.

In a number of sovnarkhozes with a well-developed nonferrous metallurgy, analogous measures were taken to combine kin enterprises. Thus, in the Vostochno-Kazakhstanskiy Economic Administrative Rayon ore mines, individual shops, etc., were amalgamated into a single polymetal combine. Metallurgical and chemical plants were combined in a number of rayons, and this has served to increase industrial output. Thus, at the Krasnoural'sk Plant, the output of sulfuric acid increased by 10.5 percent in comparison with 1957, and the percentage of utilization of the sulfur contained in gases climbed from 71.5 percent in 1956 to 85.2 percent in 1958.

Major measures for combining production were taken in the forest industry. The Sovnarkhoz of the Arkhangel'skiy Economic Administrative Rayon conducted in 1957-1958 the merging of enterprises on the basis of a rational combination of technological processes and comprehensive utilization of timber. Lumbering, sawmill, timber-processing, and pulp and paper enterprises were merged into industrial combines. In Arkhangel'sk two timber plants and a sulfate-pulp plant were merged into the Solombal'skiy Paper and Timber Processing Combine. Six separately existing plants

were merged into three sawmill and timber processing combines. The Onega sawmill and hydrolysis plants were included into a sawmill-hydrolysis combine, 22 lumbering stations were liquidated, and so forth.

Such combining had resulted in increasing the technical and economic indexes of timber processing. The Solombal'skiy Combine in 1958 had ceased to use quality timber and changed over nearly completely to the processing of sawmill wastes. In 1958 the total expenditures per ruble of commercial output at that Combine had decreased by over two percent in comparison with 1957, and the administrative-management expenses -- by 15 percent. For the Sovnarkhoz as a whole, the administrative-management personnel in 1958 was trimmed by nearly a thousand persons or 15 percent compared with 1957. The materialization of rational forms of combining by the Arkhangel'skiy Sovnarkhoz created the premises for a broad specialization of production in timber-processing enterprises. All the sawmill plants were specialized in line with the nature of their production.

The technical and economic premises for creating combined enterprises based on a comprehensive utilization of common raw material, unity of technological processes, and mutuality of territory, exist in many economic rayons. Nonetheless, certain sovnarkhozes do not merge kin enterprises into combines.

A characteristic feature of combining is the expansion, in the enterprises, of the consecutive stages of the processing of raw material and the fabrication of a product requiring less labor outlays for its subsequent processing. According to concrete conditions, either raw material shops or shops for producing output in a more finished commercial form are built as main shops. Typical examples are provided by chemical plants. In the plants of the Gor'kovskiy and Tul'skiy sovnarkhozes, capital construction is in progress for the purpose of organizing the production of their own acetylene from natural gas. This will make it possible to discontinue the deliveries of expensive and difficult-to-ship calcium carbide.

The coke-chemical plants are building shops for the production of phthalic anhydride -- the starting raw material for obtaining plastics and pigments -- on the basis of the processing of raw naphthalene. At such an organization of coke-chemical plant production, combining is extended in depth, comprehensive utilization of tars is expanded, the superfluous intermediate stages of bringing naphthalene up to the technical standards required by the plants-users of phthalic anhydride are liquidated, etc. All this considerably reduces the production costs, cuts the unit capital

expenditures per output unit, simplifies processes, and narrows the gap between the working period and production time.

Further impetus should be given to the combining of the "energochemical" processing of black and brown coals and other forms of [power-generating] solid fuel. The coke-chemical industry remains a major source of chemical raw material for the production of synthetics. In particular, it is economically expedient to build in coke-chemical plants installations for obtaining ethyl benzene from the ethylene and benzene of coke-chemical gas. In the coke-chemical plants of the Stalinskiy Sovnarkhoz this trend will be followed while materializing, during the seven-year period, a broad program for increasing chemical output. Thus, while the output of coke will increase by 124 percent, the output of chemicals during the same period will increase by 175 percent.

The prospects for the development of combining are the most favorable in the chemical and petrochemical industries. The complex character of the raw materials used, the common nature of technological processes, and other features distinguishing a number of types of chemical production, including organic synthesis, make it possible to create the most economical combined enterprises. Thanks to the combining of nitrogen plants with other enterprises a saving on the scale of not less than 800 million rubles will be achieved during the seven-year period. However, the nitrogen industry still contains other additional potential for increasing the efficiency of its production. In particular, the use of natural gas in blast furnaces serves not only to increase furnace productivity and to reduce pig iron production costs but also to use the coke gas thereby freed in enormous quantities, for the production of ammonia. In its technical and economic indexes this path is the most economical, as can be seen from the calculations tabulated below (in percent):

Kind of Raw Material	Production Cost per ton of Ammonia	Unit Capital Investments per ton of Ammonia
Natural Gas	100	100.0
Coke Gas	85	73.8
Coke	162	131.5
Coal	153	--

The high economicality of coke gas creates the possibility for a broad organization of the production of

synthetic ammonia from that gas. In our country plans exist for building, during the current seven-year period, large installations for obtaining ammonia from coke gas in a number of metallurgical combines, including the Novo-Lipetsk, Cherepovets, and other combines. In our opinion, it is expedient to organize the combined production of ammonia and other chemicals in the metallurgical plants of the Urals and Donets Basin.

Great prospects are offered by the further extension in depth of combining on the basis of a comprehensive utilization of raw materials in nonferrous metallurgy. The economic importance of this trend can be illustrated by the example of sulfuric acid, whose output in 1965 should double in comparison with 1958. One of the paths for achieving such a rise in output is the creation and expansion of the combined production of sulfuric acid. Calculations show the high effectiveness of the production of sulfuric acid from the waste gases of nonferrous metallurgy, as can be seen from the following data (in rubles):

Index	Sources of Raw Material for the Production of Sulfuric Acid			
	Natural Sulfur (After Project Data)	Pyrite From Flotation	Gaseous Sulfur	Hydrogen Sulfide Obtained During Purification of Petroleum Gases and Petroleum Products
Capital Expenditures on Creating Output Capacities, per ton per year -- total	403	264	200	133
in which:				
On Creating Raw Material Base	286	10	--	--
On Processing	117	254	200	133

The combining of production during the seven-year period alters radically the structure of the sources of raw

materials for sulfuric acid, as can be seen from the following data (in percent):

/Raw Material for Sulfuric Acid7	1956	1965
Pyrite	67.0	41.9
/Natural7 Sulfur	14.5	18.8
Sulfur-Bearing Gases	18.5	39.3
Total	100	100

As one of the principal forms of organization of industrial production, combining reflects the objective development of productive forces. The comprehensive utilization of natural resources on the basis of combined production is becoming an economic necessity. In 1958 the total amount of primary raw material for industrial processing in our country had amounted to not less than two billion tons, compared with 800 million tons in 1950. The gross industrial product and the volume of processed raw material had during the same period increased two and one-half times. During the seven-year period the amount of extracted natural raw materials will attain a still larger scale. Comprehensive utilization and the need for an omnilateral reduction in hauls of the raw materials containing various kinds of ballast in the form of gangue, water, etc., and the upgrading of raw materials directly on the extraction sites, require a further extension in depth of combined production.

The previously existing administrative barriers used to complicate a rational management of the preparation of raw materials on their extraction sites. For instance, the expediency of the in situ concentration of Krivoy Rog ores was obvious. Nevertheless, until 1957 approximately 90 percent of Krivoy Rog ores used to be shipped in unconcentrated form, together with gangue. The shipment of concentrated ore requires a twice as small amount of rolling stock, and it would serve to save the State tens of millions of rubles annually. At present the Dnepropetrovskiy Sovnarkhoz is conducting a broad program of construction of ore concentrating enterprises.

The gigantic scale of industrial, transport, housing, and civic construction in our country causes an enormous demand for forest materials. To satisfy this demand, it is

necessary to ensure the further development of the forest industry. When determining the concrete volume of production of forest materials for the forthcoming period, it is necessary resolutely to alter the previous paths of development of the forest industry.

Enormous losses have been previously allowed to occur during all stages of the cutting and processing of timber. The wastes exceed 60 percent of the total volume of cut timber, and less than one-fourth of these wastes is utilized as fuel and raw material for industry. And yet, timber wastes are full-value substitutes for commercial lumber. They can be used to manufacture glued millboard, wood-shaving board and cardboard, many chemicals, ethyl and methyl alcohol, furfural -- a raw material for the production of plastics -- colophony, fodder yeasts, etc. A large amount of timber wastes can be used instead of standard timber for processing into woodpulp. Another shortcoming of the development of the forest industry has been the territorial dispersion of the processing of timber and the haulage of timber over great distances.

The principal path for overcoming the drawbacks in the performance of the forest industry lies in the further development of combining. Calculations of the Scientific Research Economic Institute of Gosplan USSR show that by the end of 1965 the level of combining in the production of sawmill materials will reach approximately 40-45 percent, and in the production of cardboard -- 20-25 percent. The combining in the production of paper will remain on its present level of 14 percent. To obviate unrational hauls of an enormous amount of paper, it is expedient to print mass editions from matrices directly in the papermaking enterprises. This will necessitate the construction of printing shops in pulp and paper combines, which should present no special difficulties. Moreover, this measure will make it possible neither to destroy nor to ship the typographical paper wastes, and instead to reprocess them in situ. The broad development of the processes of combining in the forest industry will yield a considerable (upward of one billion rubles) saving in capital and operating expenditures.

In the food industry the combining of production also is a major source for raising labor productivity and increasing output. The creation of food enterprises on the basis of the unification of successive processing stages and comprehensive utilization of raw materials, will save the State substantial capital investments and shorten the periods of the activation of new output capacities.

Combining in the food industry should be conducted, taking into account the specific features of its raw mater-

ials and technology, along several-different trends. The agricultural raw materials proceeding for industrial processing are fundamentally complex raw materials containing many useful and necessary products. For instance, as a result of their comprehensive processing, 20 tons of sugar beets can yield 3.5-4 tons of granulated sugar, 300 liters of alcohol, 160 kilograms of carbonic acid, 111 kilograms of citric acid, 50 kilograms of yeasts, glycerine, ester-aldehyde fraction, pectin, "zhom" /sugar beet refuse/, etc. The comprehensive processing of animal raw material, meat and milk also yields numerous products.

The peculiarities of agricultural production result in the seasonal nature of operations of the processing enterprises. Thus, vegetable and fruit canning plants operate on the average 30 to 40 days a year. For the remaining time they lie idle, which is detrimental to the country's economy. Experience shows that the combined or joint production of food products makes it possible to produce a considerable amount of additional output. Thus, there is the positive work experience of one of the shops of the Canning Plant imeni First of May in Moldavia, which has converted to conjoint production. Previously that shop canned only pea and corn, but now it is also canning meat-vegetable and other foods. The organization of such production in a new place would have required 12-15 million rubles.

Considerable prospects are unlocked by combining in the field of a more complete utilization of the various plant maintenance services, e. g., elimination of the shut-downs of lime kilns during the inter-season period in the country's sugar factories will, as shown by calculations, make it possible to produce an additional million tons of construction lime, which amounts to 10 percent of its total output in the plants of the building materials industry.

The economic effectiveness of efficiently organized combined enterprises in the food industry is exceptionally high. The construction of combined enterprises for the production of sugar, canned foods, dairy products, etc., makes it possible to halve the capital expenditures and to reduce by approximately 40 percent the operating expenditures, and, most important, to shorten the time of activation of new output capacities. Calculations show that the construction in the Kuban' of 14 new sugar factories with shops for processing milk, fowl, meat, etc., will yield, after the first battery of shops is built alone, about 200 million rubles in savings.

The savings yielded by combining in the individual branches of the food industry reach a considerable scale. For instance, the construction of a standard milk processing shop within a sugar or canning factory will yield five

or six million rubles in savings at a total estimated cost of 22 million rubles.

* * *

To solve the tasks posed by the Seven-Year Plan of Development of Industry and Agriculture, it is necessary to expand the planning work on the combining of production. The new order of drafting long-range plans of development of the national economy leaves to the enterprises considerable opportunities for combining, perfecting their organization of production, etc. After the elimination of administrative barriers the combining plan is becoming part and parcel of the production programs of enterprises and of the plans of sovnarkhozes and republics, and it is being reflected in the State plans.

The plan of development of combining is drafted mainly for the branches of industry which use raw materials requiring, in accordance with the adopted technology, comprehensive processing and waste utilization, and in which it is necessary to ensure the continuity of a unified production process through a rational combination of the successive stages of processing from raw materials through semifinished products to finished products, and for which it is necessary to reduce long-distance hauls of raw materials.

The fundamental purpose of the plan of development of combining consists in uncovering -- on the scale of the branch of industry, economic rayon, and national economy as a whole -- the latent production potential for the purpose of obtaining additional output with lesser labor expenditures.

The planning organs and sovnarkhozes, when compiling plans of development of combining, guide themselves by the "Fundamental Methodological Premises for Drafting the State Plan of Development of the National Economy," drawn up by Gosplan USSR. These methodological premises include a special section expounding the basic principles and methods of drafting the plan of development of combining.

When drafting their plans of development of combining, the planning organs and sovnarkhozes should take into account the broad diversity of the forms and trends of these plans as affected by local conditions in individual economic administrative rayons.

The methodological directives consider the fundamental trends of the further development and perfection of the combining of production. In this connection, they concern combining on the basis of:

(1) Utilization of the products of petroleum refining such as refinery waste gases, aromatic and paraffinic products and other wastes and side-recovery and natural gases; and the products of the chemical processing of solid fuel -- coal, shales, peat -- through the utilization of the by-products such as tars, gases, sulfur, ammonia, etc.;

(2) Comprehensive and efficient utilization of the variegated timber wastes obtained in all stages of the cutting and processing of timber in pulp and paper, timber-processing, hydrolysis, sawmill, and other enterprises;

(3) Ferrous-metallurgy production, encompassing enterprises with a total or partial production cycle of the dressing of coal, coke-chemical plants, production of refractories and building materials, chemicals, nonferrous metals, etc.;

(4) Nonferrous-metallurgy production, encompassing enterprises for ore concentration and metallurgical reduction, for the purpose of an economically effective utilization of valuable side components, and production of building materials, chemicals, etc.;

(5) Processing of raw materials in the kin enterprises of the textile, leather and other branches of the light industry;

(6) A fuller and more competent utilization of the processed basic and auxiliary materials and of the common nature of technological processes, and omnilateral combination of successive stages for the purpose of creating a unified production process through the elimination of superfluous unproductive stages (e. g., secondary evaporation, liquefaction of a product, etc.) and loading-unloading operations, eliminating intermedicate depots for the storage of raw material reserves, etc.;

(7) The fullest and most efficient utilization of the raw materials and production wastes of the power-generation and plant operation, and of the general production space in enterprises of the food industry mainly along the line of branches of canning, sugarmaking, meat-and-dairy, and oil-and-fat production, which are seasonal in character;

(8) Comprehensive energotechnological utilization of solid fuel so as to obtain electrical energy, gas, chemical intermediates, and building materials.

When uncovering the possible trends for further development it is necessary in every concrete case to proceed from the technical expediency and economic effectiveness of combined production.

The following indexes are of utmost importance to proper planning and further perfection of the progressive forms of organization of industrial production.

A suggested planning index is the volume of output of a given product in the natural expression, obtained through combined production, and the share of that volume in the total output of that product in the economic administrative region, republic, and the country as a whole. Such an index could be exemplified by: first, output of sulfuric acid on the basis of the utilization of sulfur-bearing waste gases obtained during the processing of raw materials in the enterprises of nonferrous and ferrous metallurgy and gas, shale, coke-chemical, petroleum-refining, and other branches of industry; second, the output of cement on the basis of the comprehensive processing of such types of multi-component raw material as nephelines, syenites, metallurgical slags, etc.

An analysis of that index makes it possible to specify the tasks for the further perfection of the combined production of a given product in the sense of investigating the composition of the raw material, devising efficient methods of processing that material through a unified continuous production process, designing improved equipment with the selection of optimal-capacity assemblies to be installed in the individual stages of the conversion of the raw material, etc.

The index of the plan of combining of production is the number of products obtainable from the processed raw material, and their value in terms of an adopted unit of measurement. This index reflects the processes of combining in those raw-material branches of industry which are characterized by the processing of a multi-component raw material. It provides an idea about the technological progress in the sense of the obtainment of new products, a more economical utilization of natural resources, etc.

Examples of that index in natural and valuated measurement units could be: yield per ton of coal-coke and coking by-products in the form of tar, light oils, ammonia compounds (in terms of ammonia sulfate), aromatic products, gas, etc., or yield of chemicals per ton of black-coal tar, or the yield of individual components from the comprehensive processing of side-recovery gases -- ethane, propane, butane, pentane, etc.

An important index of the combining of production,

and one which acquires an ever-increasing importance in connection with the enlistment of enormous masses of ore raw materials for industrial processing, is the comprehensive utilization of the valuable components of the ores of ferrous and nonferrous metals. The calculation of that index can be based on the so-called coefficient of comprehensiveness. In this connection it should be considered that the coefficient of comprehensiveness has not been universally adopted and under concrete conditions it is measured differently. In a number of cases identical metals are contained both in local ores and in imported concentrates. Therefore, when drafting the plan, it is necessary to calculate not according to the "main" metal in a given rayon, and not according to fortuitous selection, but according to the group of principal metals contained in the ore.

The coefficient of comprehensiveness, i. e., the coefficient of the completeness of utilization of the raw-material substance should, in addition to serving as the direct expression of the development of the combining process, be of major importance to planning and designing practice when drafting the plans of capital construction. This coefficient can be used as a guide for determining the trend of scientific-technical research and establishing the order of sequence of the exploitation of deposits so as to give priority to the exploitation of the deposits whose ores can be extracted with the least expenditures and with a greater effect on taking account of the time factor and production efficiency.

When drafting the plans for the development of combining in enterprises and sovnarkhozes, every individual measure should be based on the technical expediency of its materialization and justified by corresponding calculations of economic effectiveness. The following indexes should be used in composing these calculations:

(1) Reduction of rate of capital expenditures per output unit, achieved in connection with the planned combining in one or several enterprises;

(2) Reduction in production costs in connection with combining;

(3) Increase in the labor productivity in combined production;

(4) Reduction of expenditures on the extraction of the raw material comprehensively utilized in combined production;

(5) Reduction of expenditures on the shipping of semifinished products and materials through the combining of technological processes and elimination of intermediate

links in storage operations;

(6) Reduction of loading and unloading operations and elimination of the packaging of products subject to further processing through the unification of successive stages into a single whole continuous production process;

(7) Acceleration of the turnover of raw material in the sphere of material production through the elimination of the shipping of unprocessed forms of raw and semifinished materials, etc.;

(8) Reduction in fixed expenses of enterprises through combining, increase in volume of output, concentration of output, etc.;

(9) Possibility of obtaining completely new products as a result of combining (e. g., rare metals, etc.);

(10) Reduction in the yearly amount of turnover funds and acceleration of their turnoverability through the partial reduction of such expenditures as production reserves, including raw material reserves, incompleted production, finished products, etc.

The above list of indexes could be supplemented when drafting the plan of development of combining on taking into account the concrete conditions in a given republic, rayon and enterprise. It is important that the system of indexes employed in the drafting of that plan should reflect correctly the development of all processes of combining in enterprises, branches, sovnarkhozes, republics, and the country as a whole.

The following should be adopted as mandatory criteria of the economic effectiveness of the intended measures for combining: the savings in capital expenditures in the combined enterprises compared with the expenditures in the uncombined enterprises, and the savings in production costs attained in the combined enterprise, and the rise in labor productivity in that enterprise as well.

The investigation of the profile of individual enterprises for the purpose of detecting the premises for the organization of an efficient combining of production, should be based on the following technical and economic postulates:

(1) Common nature of technological processes and of the consumed types of raw material, e. g., the presence in petroleum refineries and chemical plants of processes for separating the gas mixtures obtained during the refining of petroleum and side-recovery gases, or, in addition, the presence of processes of alkylation in the same plants, for obtaining petroleum products and chemicals; or, moreover, e. g., the processing of both ore and rock raw materials into nonferrous metals, chemicals, building materials, etc.

(2) Effective utilization, at a given or neighboring enterprise, of the physicochemical properties acquired by the product itself in the course of its processing (e. g., the heat of blast-furnace slags) or in the course of the processing of the product through the individual stages of the production process (e. g., spent steam, cooling agents, hot waste gases, etc.);

(3) Comprehensive utilization of the raw material, wastes, by-products, various discards, liquid wastes containing valuable substances -- feasible only under the conditions of a combined production;

(4) Possibility of completing, at the combined enterprise, the continuous cycle of production through an efficient combination of the greatest possible number of consecutive stages of raw-material processing, as far as the finished-product stage.

The mobilization of scientific research and design institutes for the study of the problems relating to the conduct of efficient combining in rayon and republic enterprises should assure the necessary technical-economic information and appropriate consultation followed by the conduct of calculations.

The practice of the work of sovnarkhozes on the further development of combining in industry shows that this entails new premises which have to be considered when drafting the plan.

The plans of combining production are drafted in enterprises, sovnarkhozes, and republic gosplans, according to branch and type of production. These plans should include the following measures: unification and merger of kin enterprises and shops for the purpose of a comprehensive utilization of mineral and agricultural raw material, and fuel as well, in the existing and newly planned enterprises; cooperation among enterprises, including the seasonal enterprises, to ensure a concerted utilization of output capacities, and increase in the output of finished products and the reduction of losses and wastage of raw material during prouduction; and the construction of new combined enterprises.

The methods of drafting plans of development of combining need, naturally, further improvement and perfection on the basis of the study and generalization of the experience of the work of sovnarkhozes and pace-setting enterprises. A proper organization of the planning of the processes of the development of combining in all links begining with the enterprise and ending with Gosplan USSR will be conducive to the most rapid elimination possible of the

existing shortcomings, and it will be a formidable source of a further rise in the productivity of social labor and realization of the historic decisions of the 21st Party Congress.

c. Questions Concerning the Full Utilization of Raw Materials in the Metallurgical and Chemical Industry of Kazakhstan

/This is a translation of an article written by K. Akhmetov and V. Bessonov in Planovoye Khozyaystvo (Planned Economy), No. 1, January 1960, pages 82-86./

One of the main ways of increasing the scale of social production and reducing the rate of production expenditures is the comprehensive utilization of raw and other materials and power. Particularly acute is the problem of the comprehensive processing of raw material in the nonferrous metallurgy of Kazakhstan on the basis of the perfection of technological processes, and the cooperation and combining of enterprises of this branch with the chemical industry.

The large quantities of multi-component -- i. e., containing, in addition to copper or lead, zinc, sulfur, iron, and precious and rare metals -- pyrite ores of the Urals, Altay and other deposits, continually arriving in the enterprises of nonferrous metallurgy, are a most valuable industrial raw material. They are important to a nearly equal degree in both the metallurgy of heavy nonferrous metals and the production of sulfuric acid and metallic chemicals and pigments.

However, because of the administrative barriers between the metallurgical and chemical enterprises, the effectiveness of utilization of these ores has hitherto been low. This pertains primarily to the utilization of the sulfur arriving together with the ores and concentrates in the plants of nonferrous metallurgy and passing, during the processes of metallurgical reduction, into sulfur-bearing waste gases. The utilization of these gases makes it possible to produce sulfuric acid with minimal capital expenditures on the construction of sulfuric-acid shops and at considerable savings in operating expenses. To provide for the consumption of that acid directly on the site of its production, it is necessary for nonferrous metallurgy to cooperate with chemistry for the purpose of establishing within the framework of a number of nonferrous-metallurgy combines the various types of sulfuric-acid production -- ordinary and double superphosphate, cryolite, etc. Such sulfuric-acid shops could primarily be organized most expediently in the combines located in the regions of demand for phosphorous fertilizers (Altay, South and Central Kazakhstan). The in-

corporation of the production of double and ordinary superphosphate into the framework of the nonferrous-metallurgy combines producing sulfuric acid and operating highly developed plant facilities makes it possible to reduce by 60-70 percent the capital investments in the production of phosphorous fertilizers.

Special importance is attached to the utilization of the sulfur of pyritic ores bound with iron in the form of the pyrites obtained during the beneficiation of copper, copper-zinc and lead-zinc ores. At present, 63 percent of pyrites are retreated, while the remaining 37 percent are forfeited in the dumps. Upon the retreatment of pyritic ores it would be possible to obtain elementary (the so-called gaseous) sulfur as a by-product. Thus, considerable quantities of elementary sulfur are obtained during the retreatment of cupriferous low-zinc pyrites by the method of improved pyrite melting. Methods of recovering elementary sulfur from pyrites are being successfully developed by the Scientific Research Institute of Fertilizers and Insectifungicides and the Ural Scientific Research Institute of Chemistry.

The purpose of these activities is not only to recover elementary sulfur but also to utilize more fully all the other valuable components of pyritic ores -- nonferrous, precious and rare metals, and iron as well. In the process of beneficiation the following metals pass into the pyritic slime concentrates in addition to the sulfur-bound iron: gold -- 57-60 percent; silver -- 45-47 percent; copper -- 10-12 percent; rare and dispersed metals -- 70-80 percent; and also a part of lead and zinc. The value of these metals in, e. g., one ton of pyritic concentrate at the Leninogorsk Concentrator Plant, amounts to approximately 700 rubles according to the current sales prices of finished production. At present, however, all this value is essentially lost either in the dumps of concentrator plants or in the pyritic cinder dumps of sulfuric-acid installations and in pulp and paper enterprises.

The organization of the retreatment of the pyritic cinders obtained in the process of the roasting of sulfur pyrite and pyrite concentrate would make it possible to obtain from them in 1965 as much as three million tons of pig iron, over 20,000 tons of copper and zinc, and a considerable quantity of precious and rare metals. To solve this problem, it is necessary to organize directly on extraction sites the recovery of the elementary sulfur contained in the pyritic copper and copper-zinc ores, to be coupled with the maximal recovery of all nonferrous, precious and rare metals and the obtainment of a ferruginous residue suitable for retreatment

into pig iron.

The solving of the problem of the comprehensive retreatment of pyritic ores is of particular importance at present, when the next few years will witness the starting of the exploitation of a Rudnyy Altay deposit the bulk of whose ores is pyritic. The application of the conventional scheme of retreatment to these ores would lead to the loss of 70 percent of the valuable components they contain. By now it is necessary to enlist the interest of chemists and metallurgists in devising the technology of retreatment of these ores.

The materialization of measures for the further development of the merging of Kazakhstan's metallurgical enterprises and their cooperation with chemical plants requires of the central and republic scientific-research and project-design organizations the solving of a number of tasks as early as within the next few years. It is primarily necessary to conduct laboratory studies and semi-industrial tests of the processing of massive pyrites into elementary sulfur and a residue suitable for metallurgical retreatment. The residue thus obtained should be investigated to determine the optimal scheme for its retreatment by several methods. At the same time, it is necessary to complete the experimental smeltings of copper concentrates and cupriferous intermedicate products of suspended-state concentration (including cyclone smelting) yielding a sulfur-bearing gas suitable for the production of sulfuric acid, and all easily volatile components in the form of fumes and slimes.

The development of the mining and metallurgical, power and machine-building industry and the ever-increasing volume of construction as well, require the expansion of the variety and volume of the deliveries of the most variegated paint and lacquer materials to the economic rayons of Kazakhstan. Annually over 6,000 tons of natural and artificial drying oil and many zinc whites, red leads, ultramarines, solvents, and other products have to be imported into that republic. At the same time, thousands of tons of industrial vegetable oils for the production of drying oils and a large amount of metallic zinc for the production of zinc white are being exported beyond the republic's confines. It would be rational to organize the in situ production of drying oil and pigments.

For a long time now the production of zinc whites has been based fundamentally, and unrationally, on the use of high-quality electrolytic spelter. The production of zinc whites from metallic zinc leads to superfluous consumption of electrical energy and pure metal during the conversion

of zinc into zinc oxide in the enterprises of the paint and lacquer industry.

The consumption of sizable quantities of metallic ingot zinc on the production of whitings cannot be tolerated any longer, because whitings could just as well be produced in the plants of nonferrous metallurgy from semifinished products and wastes. For this purpose, it is necessary to assure cooperation between the enterprises of ferrous metallurgy and the paint and lacquer industry and to organize the side production of metallic chemicals and pigments. The experience of the domestic enterprises, and foreign practice as well, shows that in the zinc and lead plants it is possible, in addition to their basic production, to fabricate on the side thousands of tons of sulfate salts, iron, copper, zinc chloride, white lead and zinc white, and other products. Such "side production" not only does not interfere with basic production but also makes it more profitable in view of the great demand for these products.

At present the State Scientific and Technical Committee USSR has outlined a number of measures for the organization of the industrial production of zinc whites from zinc-bearing raw material -- upon by-passing the stage of the obtainment of metallic zinc -- directly in certain nonferrous-metallurgy enterprises, and it has adopted a broad program for scientific-research, design and experimental and project-drafting activities in this direction.

During the conduct of the above measures it is necessary to guard against the diversion of attention from the most pressing fundamental problems to secondary or even tertiary problems. The latter problems include, in our opinion, the development of methods of producing whitings not only from the wastes and semifinished products of nonferrous metallurgy but also from such a principal raw material as sulfidic zinc concentrates.

At present the basic problem consists not in the development of the production of high-grade whitings for the rubber and tire industry (the demand for these whitings can be satisfied by their present production from metallic zinc) but in the organization of the production of zinc chemicals and pigments during the retreatment of zinc-containing scrap, zincing wastes and zinc drosses and, as well, directly from the zinc-containing semifinished products and wastes of nonferrous metallurgy which are at present "immobilized" in dump heaps.

In this connection, it will be possible to satisfy the rapidly rising demand for zinc chemicals and pigments without any major investments in the construction of new zinc plants and the establishment of fuel and power bases

for these plants, and with lower labor outlays. The production of zinc chemicals and pigments during the retreatment of scrap, zincing wastes and zinc drosses will obviously develop in accord with the envisaged rapid rise in the production and consumption of metallic zinc. However, the greatest attention should be devoted to the organization of the production of zinc chemicals and pigments in those nonferrous-metallurgy enterprises which have been and are accumulating considerable quantities of zinc in dumps and wastes. This pertains primarily to the metallurgical plants of Rudnyy Altay.

The Soviet industry uses many methods for obtaining zinc and lead in the forms of oxides during the retreatment of zinc cakes and zincous slags. These methods could be utilized for the production of zinc chemicals and pigments. The most suitable raw material for this purpose is the slags of copper smelting in the copper-smelting plants. The possibilities of obtaining commercial zinc oxide from slags should be investigated primarily at the Irtysh Plant, because in that plant the slags cannot be conveyed to an installation for their retreatment in molten form. In addition to the granulated slags from current melting operations it is possible to retreat within approximately 10 years all the slags accumulated in that plant's dump yards.

The creation at the Irtysh Plant of a slag-retreating installation serving to obtain zinc oxide for the needs of the paint and lacquer industry is not the only solution. Of exceptionally great practical interest to the nonferrous metallurgy of the Altay is a procedure now being developed at the Gintsvetmet /State Institute of Nonferrous Metals/ and based on the obtainment of a low-moisture microcrystalline zinc vitriol by the methods of instantaneous evaporation of the solution by spraying the solution into a jet of heated gas (air, combustion products), with subsequent heat decomposition. The sulfur of the waste gases can be utilized at a sulfuric-acid installation.

To Altay the utilization of the zinc sulfate solution is of special importance in view of the broad development which should be experienced there by the sulfating retreatment of the dusts of sintering and lead melting, fumes of the Waelz treatment of the slimes of blast-furnace dusts of the Kuznetsk Metallurgical Combine, zinc cakes, and other similar materials.

The Gintsvetmet and Vniitsvetmet /All-Union Scientific Research Institute of Design and Planning of Nonferrous Metallurgy/ should resolve the question of the methods of the additional utilization of zinc-production solutions in Altay's enterprises for the purpose of producing zinc oxide

by the thermal decomposition procedure, and they should provide the starting technical data to a project-design organization so as to enable it to interrelate the designing of installations for the sulfating of dusts and zinc cakes and for the production of zinc oxide from the zinc-sulfate solution.

In our opinion, it is necessary to organize side production of copper sulfate in the zinc plants. The product obtained as a result of the decoppering of zinc solutions is more convenient to retreat into chemicals than to transmit to copper-smelting plants. However, at present the Ust'-Kamenogorsk Lead-Zinc Combine does not recover its copper into its commercial production and instead lets it pass into clinker and lead and copper cakes requiring additional retreatment. It is expedient to use them for producing copper sulfate on the basis of a sulfating method developed by the Vniitsvetmet. At present, work innovators together with scientific research workers are drafting measures for the technological introduction of that method.

To the technology of zinc and lead production it is of extreme importance to prevent the circulation of arsenic in processes: arsenic is a harmful impurity and it causes losses of the principal recovered metals. It is necessary to solve the problem of extracting arsenic from the process and converting it into arsenic products. This last is of special importance, because of the accumulation of a large amount of arsenous returns in the plants of nonferrous metallurgy.

A broad and important range of application has at present been found for arsenic. In Sweden, e. g., was developed an arsenic preparation for preserving wood. That preparation can be used to treat crossties, pillars, bridge supports, mine timbering, etc. The simplicity and low cost of such preservation, its long-lasting effectiveness and its resistance against leaching by aggressive waters cause it to be immensely valuable for preserving the tremendous quantities of timber used in railroad construction, mining, and other branches of the national economy of the USSR.

The Central Scientific Research Institute of Mechanical Processing of Wood should accelerate its development of data for the designing of a shop for the production of antiseptics on the basis of the arsenous wastes and salts of copper and zinc.

Kazakhstan is endowed with raw materials not only for metallurgy but also for the chemical industry. Therefore, the firm establishment of cooperation between the enterprises of these two industries is a most important national-economic task. Central Kazakhstan should become a major region of the production of synthetics and other types of

chemicals. The base for establishing there an industry of organic synthesis, including plastics and artificial fibers, is the methane from Karaganda mines, the gases and liquid products of coke-chemical industry, and the natural gas transmitted through pipelines. On the basis of these raw materials it is possible to organize a major industry of plastics, synthetic fibers, etc.

It is known that the extraction of coal in the mines of the Karaganda Basin is at present accompanied by the expulsion into the air of as much as 250 million cubic meters of methane annually -- and methane is a starting raw material for the production of polymers. An efficient utilization of methane, degassing of mines, is of great national-economic importance. In the Soviet Union work is in progress on an efficient utilization of mine methane. Thus, in the city of Stalino a special agency has been established for drilling gas-drainage holes, laying gas pipelines and utilizing methane.

The Karaganda Coal Basin is one of the principal methane producers in the Soviet Union. The volume of methane extracted there daily in 1959 suffices to satisfy the fuel needs of over two thousand trucks. The utilization of methane represents a considerable potential for saving on coal and electrical energy and for substantially improving the material conditions of workers.

The production of ion-exchange resins, flotation agents, pesti-, fungi- and herbicides, ammonia, plastics, liquid motor fuel, and other products, could also be organized on the basis of low-temperature carbonization and energotechnological utilization of resinous and brown gas coals. The processing of gases could make it possible to set up there a large-scale industry of synthetic fiber -- "nitron" for the manufacture of high-quality wool and silk fabrics.

Enormous and variegated resources of chemical raw material exist in West Kazakhstan. There, the reserves of natural gas are estimated at many hundreds of billions of cubic meters, and substantial reserves of petroleum are present.

The chemical industry of West Kazakhstan could in the immediate future be based on the wastes of the Gur'yev Oil Refinery, gases of the currently exploited oil fields, deposits of chromites, potassic, magnesial and other salts, phosphorites, combustible shales and, in addition, the reed-grass reserves of the northern coast of the Caspian Sea.

On the basis of the utilization of the substandard ores of chromitic deposits it is expedient to establish a large sodium bichromate industry. The chemical processing

of the reedgrass of the northern coast of the Caspian Sea, lower courses of the Syr-Dar'ya, Southern Pribalkhash'ye and Upper Irtysh, can serve to produce pulp, furfural, and container cardboard. The known reserves of potassium, magnesium, sodium and other salts, and gypsum and sulfates as well, are able to satisfy fully the demand of Kazakhstan and West Siberia for potassic fertilizers, hydrochloric acid, soda, gypsym products, and many other types of production.

The upsurge in the chemical industry and the industrial introduction of new chemical processes, directly entail the problem of the comprehensive utilization of raw materials. The "chemicization" of branches of the national economy, in particular nonferrous metallurgy, ensures the inclusion of new types of raw material into production. At the same time, it fosters the intensification and growth of the output of nonferrous metals and other valuable elements.

The plans for 1959-1965 envisage capital construction on a gigantic scale, and therefore the increase in the economic effectiveness of capital investments is acquiring an exceptionally great role in the seven-year period. It is necessary to determine profoundly and circumstantially the economic effectiveness of the introduction of chemical methods of product processing and chemical processes in, primarily, nonferrous metallurgy. This is dictated by the fact that the current methods of beneficiation of copper and lead-zinc ores lead to the loss of the bulk of many valuable elements in ore tailings. The greater part of the rare and dispersed metals passing into concentrates during beneficiation later on passes into dusts and slags during metallurgical reduction. A great amount of these elements is also lost in the slags of copper and lead smelting.

The Seven-Year Plan of Development of the National Economy provides for the construction of slag-fuming installations in lead and copper-smelting plants to be accompanied by the construction of shops for the retreatment of dusts and oxides. However, the designs drafted for such shops do not provide for the recovery of all of the elements contained in the dusts and fumes. To introduce chemical processes in nonferrous metallurgy, it is necessary to organize within the framework of the Vniitsvetmet Institute an applied chemistry laboratory, and at the Kazgiprotsvetmet /Kazakh State Institute for Design and Planning of Nonferrous Metals Industry/ -- a department for devising chemical types of production on the basis of a comprehensive utilization of the raw material, semifinished products and wastes of Kazakhstan's nonferrous metallurgy.

Of extreme importance is the conduct of research in the economic foundations for the introduction of new technolo-

gy in chemical types of production, the development of methods of economic calculation for selecting the optimal versions of progressive technological processes and enlarging and introducing new, combined technological installations. For this purpose, at the Institute of Economics of the Academy of Sciences Kazakh SSR it is necessary to set up a team of economists to investigate new technology and progressive technological processes in chemical types of production.

An economic analyses of organizational forms of development of the nonferrous metallurgy shows that the combining of production processes in this branch is extremely effective. In a large combine with efficiently arranged production ties it is possible to employ such a combination of progressive technological processes as would ensure a comprehensive and maximally complete utilization of the starting raw materials, semifinished products and wastes, and power resources as well. However, the problems of the combining of production processes are as yet being slowly resolved in the republic, despite the existing opportunities.

Combined production is characterized by a substantial decrease in unit capital expenditures, resulting from the enlargement of technological installations; this includes expenditures on transport, auxiliary accommodations, residential and civic construction, etc.

The problems of the combining of chemical types of production, and particularly the problems of the comprehensive energochemical utilization of fuel, deserve careful attention of our planning organs, need to be investigated and require major economic studies.

A proper organization of planning is of great importance to a proper solving of the problems of the specialization and combining of nonferrous metallurgy with the chemical industry in the economic administrative organs. The Gosplan Kazakh SSR should draft plans of inter-rayon production of ties, specialization and cooperation of industry on the basis of an omnilateral study of the needs of the national economy and technological progress and of the possibilities for a comprehensive utilization of the production and raw-material resources of every rayon.

The multilateral development of the economic administrative rayons is not tantamount to establishing all branches of industrial production in each such rayon. The present territorial specialization of the leading branches of industry in the Soviet Union will continue to be consistently perfected and expanded. It is in the interest of the State as a whole to develop in every individual rayon only

such branches of industry as meet with the most favorable local conditions for achieving a high productivity of social labor and reducing production outlays.

The solving of the now ripe problems of the cooperation and combining of metallurgy with chemical industry in Kazakhstan is the cardinal prerequisite for a further increase in the pace of expanded socialist reproduction, technological progress, multilateral development of economic rayons, and a more rational hauling of freight in our country.

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